# Evaluation of GPM-Era Constellation Precipitation Estimates for Land Surface Modeling Applications

**F.J. Turk[1] V. Anantharaj[2] G. Mostovoy[2]**

*[1]Naval Research Laboratory, Marine Meteorology Division, Monterey, CA 93943*
*[2]GeoResources Institute, Mississippi State University, Starkville, MS 39762*

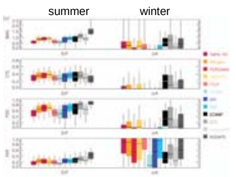
**SUMMARY** With changes to satellite missions and sensor capabilities, it is likely that the GPM constellation configuration and the types of sensors contributing to the combined-sensor HRPPs will be known until close to deployment, and will change during the lifetime of GPM. It is instructive to note how the retention or loss of a particular satellite platform and/or sensor type will affect the performance of the HRPPs and applications that utilize GPM products. In this study, we use existing (2008) active/passive microwave-based platforms to examine the impact of several proxy GPM satellite constellation configurations on one such HRPP over the continental United States. The validation is presented two ways. The first is by traditional validation using existing a surface gauge network analysis (Chen et. al, 2008). The second is more indirect, through examination of how the soil moisture state of the Noah land surface model (LSM) is impacted when the LSM is driven with different precipitation datasets, corresponding to several proxy GPM constellation configurations.

## Background

High resolution precipitation products (HRPPs) combine a multitude of spaceborne remotely-estimated and ground-based datasets in order to generate a precipitation product that is of a finer spatial and/or temporal resolution than any of the individual input datasets. These HRPPs are relevant to a variety of applications relating to Earth's hydrological cycle. Sensors onboard low Earth orbiting (LEO) and geostationary environmental satellite systems provide the basic building blocks of an HRPP, augmented in some cases by surface radar and raingauge information and analyses from numerical weather prediction (NWP) models. In order to find their widest usage and impact, the specification of the error structure of each HRPP should align with user requirements. To assess the status and requirements for HRPP error analysis, the first workshop of the Program for the Evaluation of High Resolution Precipitation Products (PEHRPP) was convened at the World Meteorological Organization (WMO) headquarters late in 2007. Over 40 attendees from 12 countries presented with working group reports on applications, validation and error metrics. Presentations and report online at http://www.isac.cnr.it/~ipwg/meetings/geneva/geneva2007.html.

PEHRPP

**Seasonal Performance**
**Australia Tropics (> 1 mm/day)**



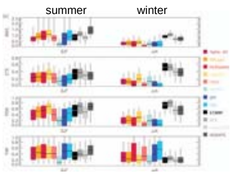

Bias

Equitable Threat Score

Probability of Detection

False Alarm Rate

**Seasonal Performance**
**Australia Mid-Latitudes (> 1 mm/day)**




PMW + IR METHODS

IR-ONLY METHODS

NWP MODELS

From an over-land validation of 12 HRPPs and 4 numerical weather prediction (NWP) models done on a daily time scale and 25-km spatial scale, Ebert et. al (2007) noted that HRPP-derived occurrence and amount are most accurate during summer months and lower latitudes, whereas the models exhibit superior performance during winter months and higher latitudes. HRPP estimates showed improved performance compared to NWP model for convective type precipitation, and an opposite behavior for lighter, stratiform precipitation.

*Figure courtesy of Beth Ebert*

## GPM Synergies with the Soil Moisture Active Passive (SMAP) Mission

GPM is currently planned to be active during the Soil Moisture Active Passive (SMAP) mission. There exists significant GPM-SMAP overlap in terms of science goals and measurement requirements, specifically towards the utilization of frequent precipitation estimates. For example, SMAP can benefit GPM over-land retrievals via improved dynamical characterization of GMI channel surface emissivities, and GPM can benefit SMAP science through the capability for improved tracking of precipitation evolution between SMAP revisits.

GPM constellation-derived precipitation products

Improved over-land precipitation retrievals

Knowledge of precipitation evolution between SMAP revisits

Improved land surface emissivity state at GMI channels/polarizations

Improved precipitation as forcing for land surface and hydrological runoff models

Verification of LSM soil moisture/state

SMAP retrieved soil moisture/state

Improved remotely-sensed soil moisture compared to current AMSR-E

Measured soil moisture, runoff, streamflow

Verification and impact of SMAP and GPM datasets

## Gauge-based Impact and Verification

In order to examine the impact of particular satellite types, crossing times and sensor types (conical or crosstrack), the NRL-Blend technique (Turk and Miller, 2006) was run in ten parallel modes, each employing different combinations of satellites and sensor types. The ground truth data used is the optimal interpolation (OI) global daily analysis provided by NOAA/CPC (Chen et. al 2008) over the continental United States during two 3-month periods, Jun-Aug 2007 (JJA) and Dec 2007-Feb 2008 (DJF).

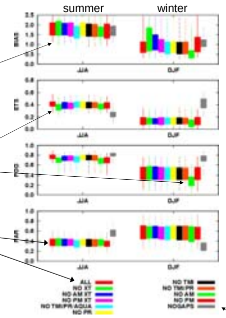
**Overall performance degradation over western US compared to eastern US (difficulty of PMW scattering-based techniques over complex terrain)**

Not much difference amongst sat-omission runs for the NRL-Blend "adjustment-based" HRPP technique

Green box illustrates largest performance impact is the omission of the morning overpass crosstrack sounders ("No AM XT" and "No AM" configurations)

**ALL Satellites Case**
NOAA 15/16/17/18 (crosstrack)
METOP-A (crosstrack)
DMSP F-13/14/16/17 (conical)
Aqua (conical)
Coriolis (conical, over water)
TRMM TMI (conical), PR

**Seasonal Performance**
**West of 100W Longitude (> 1 mm/day)**



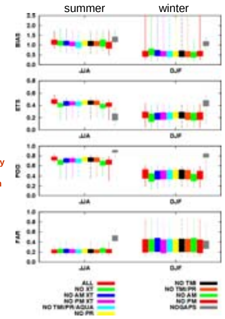

Bias

Equitable Threat Score

Probability of Detection

False Alarm Rate

**Seasonal Performance**
**East of 100W Longitude (> 1 mm/day)**



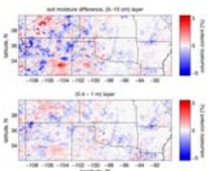

NOGAPS NWP model

The figures above illustrate the performance using the identical box-and-whiskers type presentation as Ebert et. al. (2007, left panel) and using the same 1 mm/day threshold. For example, "No AM XT" refers to the NRL-Blend precipitation estimates when all morning (LTAN near 1800) satellites with crosstrack sounders were omitted. Only one NWP model (NOGAPS) is shown (gray color).

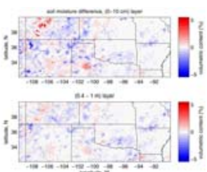
## Land Surface Model-based Impact Study

Impact and validation efforts also include the use of land surface models (LSM) and other types of hydrological observations (other than raingauge) to examine the impact of these GPM *proxy* data upon streamflow, discharge, soil moisture and other runoff measurements (some of which will be directly or indirectly inferred from a concurrent NASA mission, SMAP, see left). By employing the Noah LSM, incorporated with the NASA Land Information System (LIS), to simulate land surface and hydrological states, the performance impact of different GPM constellations can be examined (similar methodology as Gottschalk et. al (2005)). The analysis domain presented below covers the south-central United States where there are several well-instrumented watersheds. The impact of precipitation in a LSM is dependent upon many physical factors, soil type, vegetation, etc. Soil moisture analysis at a given time is likely to be the cumulative result of precipitation that has fallen for weeks or months prior. To accommodate this, the results are shown after 5 months of simulation time, valid at 18 UTC on 31 October 2007. Soil moisture simulations are performed with 0.1x0.1 lat.-lon. resolution and the North American Land Data Assimilation System (NLDAS) forcing fields (except for precipitation) are used to run the Noah LSM. The colors depict *soil moisture difference relative to the all-satellites configuration* in the upper (0-10 cm) and deep layer (0.4-1 m).

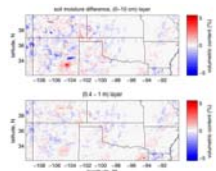
**No Crosstrack Sounders**



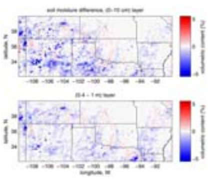
**No AM Crosstrack Sounders**



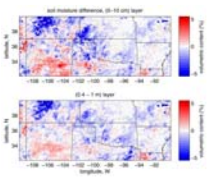
**No PM Crosstrack Sounders**



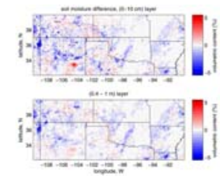
**No TMI+PR+Aqua**



**No AM Satellites**



**No PM Satellites**



As in the gauge-based verification analysis above, the greatest difference between any GPM constellation configuration compared to the "all satellites" configuration appears when the crosstrack sounders and the morning crossing (LTAN near 1800) satellites are omitted from the NRL-Blend. The removal of the morning satellites likely has less to do with the specific local time-of-day observation than it does with the fact that the bulk of the current (2008) satellites such as DMSP, Coriolis and several NOAA have early morning crossing times. While this example shows only one time step, these LSM simulations are being extended to cover DJF and JJA seasonal analyses.

**References**

Ebert, E., C. Kidd, J. Janowiak, 2007: Comparison of near real-time precipitation estimates from satellite observations and numerical models. *BAMS*, **88**, 47-64.

Gottschalck, J., J. Meng, M. Rodell, and P. Houser, 2005: Analysis of multiple precipitation products and preliminary assessment of their impact on Global Land Data Assimilation System land surface states. *J. Hydrometeor.*, **6,** 573–598.

Chen, M., W. Shi, P. Xie, V. B.S. Silva, V. Kousky, R. Higgins, J. Janowiak, 2008: Assessing objective techniques for gauge-based analyses of global daily precipitation. *J. Geophys. Res.*, **113**, D04110, 1-13.

Turk, F.J and S. Miller, 2005: Toward improving estimates of remotely-sensed precipitation with MODIS/AMSR-E blended data techniques. *IEEE Trans. Geosci. Rem. Sens.*, **43**, 1059-1069.

Turk, F.J., P. Arkin, M. Sapiano, E. Ebert, 2008: Evaluating High Resolution Precipitation Products. To appear in *Bull. Amer. Meteor. Soc.*

*The authors recognize support from the NASA Applied Sciences Program via NASA contract NNS06AA98B.*
*This work was initiated while J. Turk was supported under NASA PMM Earth Sciences grant NNG04HK11I.*